Chernobyl Straw-Man Outline

The Chernobyl Incident – Experiences, Recovery, and Lessons Learned

Introduction (3 min) – State the purpose of the documentary: In an age of growing incidence and awareness of terrorism aimed at mass casualties and disruption, the U.S. faces a risk of experiencing a "dirty bomb" or even an improvised nuclear device. EPA has been preparing for such an eventuality, and is ready to respond, if necessary.

A dirty bomb or improvised nuclear device would be likely to detonate with little or no warning and contaminate a large, densely inhabited area. To address the key issues that would confront the U.S. and in such an event, this discussion will examine an event that forced the USSR to confront some of the same issues: response and recovery from the Chernobyl nuclear incident. The Chernobyl incident was the uncontrolled meltdown of one of the core reactors of the Chernobyl nuclear power plant in 1986 near what is now Kiev, Ukraine. In this documentary, we'll examine how recovery from that that incident was managed, focusing on effective countermeasures in the aftermath of the disaster and eventual restoration and recovery of the area. We will enhance our discussion of the response and recovery from that incident with direct, first-hand, personal perspectives of an early responder who provided technical assistance in the early phase of recovery, and of a resident of Kiev, who was a young mother in Ukraine at the time of the disaster. [More detailed resumes when they first appear on screen]

This is a good place to introduce the types of incidents we might face and draw a distinction between the similarities and differences between a nuclear power plant meltdown and an RDD or improvised nuclear device.

Draw on the differences between RDD, IND, and a nuclear power plant (NPP) disaster. The common theme to draw from these events is a potential for a radiological contamination of a wide-area. We will use the Chernobyl experience to discuss the issues involved with recovery from wide-scale radiological event.

Radioactive dispersal device (RDD):

- An RDD is a conventional bomb that contains radioactive materials and scatters those materials and other debris over a small area when it detonates. This type of weapon may use medical or industrial nuclear materials, but the materials do not undergo a nuclear reaction. *Iodine 131 is not likely to be a constituent of this device, so potassium iodine tablets would not be necessary because Iodine-131 is created by a nuclear reaction.* ***<Define nuclear reaction in layman's terms [make consistent with C:\Documents and Settings\jcardare\My Documents\Reference Materials\REMM\rdd.htm]***

- An RDD would likely involve contamination over a densely populated area, initial confusion/lack of information, and an improvised response (by that I mean flying blind), but would differ from Chernobyl in that the contaminated area would be significantly smaller and the amount and intensity of radioactivity released would likely be orders of magnitude lower.

- *CDC FAQ: Although a dirty bomb could cause serious injuries from the explosion, it most likely would not have enough radioactive material in a form that would cause serious radiation sickness among large numbers of people.*

Improvised Nuclear Device (IND): An IND is a small nuclear bomb where materials undergo a nuclear reaction. An IND would be catastrophic. The contaminated area would be big but amount of contaminated land would still be smaller than Chernobyl and there would likely be mass casualties. ***[Include language about fission products, specifically I-131 which will require KI distribution to the public.] Make sure this is consistent with the REMM site.***

Nuclear Power Plant disaster – Chernobyl, three mile island.
We may want to provide a brief description on the difference between Chernobyl and TMI. John will draft this language. Why is Chernobyl not likely to happen in America?

Outline of what's to come (1 min) – road map of where we're going: Definition of terms, description of incident, immediate response, long-term response, and discussion of U.S. preparedness for such an event.

The Incident (5 min) – Discussion of what transpired. Explanation of why they had a meltdown in the first place, how the disaster unfolded, and what happened as a result. The focus of this section is what happened up to the evacuation of Pripyat. There will be good footage here that should give the viewer an idea of the magnitude of the disaster and it'll set the stage for the recovery. Also discuss fallout, what it is, heavy (hot) particles close, lighter particles far, control of wind, precipitation. ***[Note that the reactor burned for ten days, spewing radiation across 100,000s acres covering most of western Europe.]***

The Immediate Response (15 min) – Here we can talk about the liquidators (and touch on the construction of the sarcophagus and the new safe confinement, in passing). We'll certainly be able to identify some good footage/photos of this part, ***<IAEA photo library may be useful*** then we can get into the more meaty and meaningful information in the Health Physics articles. We can also discuss the fallout pattern and how it was highly variable based on precipitation (Balinov, p. 385), and what fell out where (short-lived and long-lived isotopes (nuclear reactions) ***<define these terms.*** We could introduce the concept of distance, time, and shielding here - Dose rates decreased by three orders of magnitude in the 3 km from the plant to Pripyat (Hinton et. al. p.430).

Balanov mentions evacuation, distribution of stable iodine KI tablets to Pripyat (but not the surrounding area), and restriction of the food supply as the most effective immediate measures. For the immediate affected area, outline the basic measures – establishment of 30 km exclusion zone, evacuation, nuclear waste repositories. For the larger (and more populous) area, outline other measures - bathing, clothing, hygiene … We can discuss these systematically, and we can follow each with CDC/REMM/DHS recommendations. I like that approach because we can tie together history, first-hand anecdotes, and current recommendations:

Clothing and hygiene: *Exposure to radiological contaminants through fallout is an important mechanism of exposure in the early phase of a radiological incident. Contamination refers to particles of radioactive material that are deposited anywhere that they are not supposed to be, such as on an object or on a person's skin. Internal contamination refers to radioactive material that is taken into the body through breathing, eating, or drinking. One effective way to reduce exposure is to remove clothing where particles may lodge and to shower to remove particles from skin and hair*. ***We should consider including the miniature videos of these concepts from the REMM site. We should consider dedicating a minute to describe the REMM website.***

CDC recommendations for dirty bomb: ***I prefer to reference the viewer to the REMM website for these details and spend more time presenting the environmental consequence and recovery aspects of the event.***

- *To keep radioactive dust or powder from getting inside, shut all windows, outside doors, and fireplace dampers. Turn off fans and heating and air-conditioning systems that bring in air from the outside. It is not necessary to put duct tape or plastic around doors or windows.*
- *If you must go outside, be sure to cover your nose and mouth with a cloth to reduce the risk of breathing in radioactive dust or smoke.*
- *Take off your outer layer of clothing and seal it in a plastic bag if available. Put the cloth you used to cover your mouth in the bag, too. Removing outer clothes may get rid of up to 90% of radioactive dust.*
- *Put the plastic bag where others will not touch it and keep it until authorities tell you what to do with it.*
- *Shower or wash with soap and water. Be sure to wash your hair. Washing will remove any remaining dust.*

a. Clothing – Larissa's story about the lead-lined boxes in Kiev.

b. Hygiene – Vira and Larisa recollections about official recommendations and what people actually did ***We may be able to use information from the Chernobyl documentary I viewed this weekend from the Google site.***

Food: *Internal exposure to radiological contaminants through consumption of food and water is a very significant exposure mechanism, more so for a nuclear power plant disaster of nuclear explosion than for a dirty bomb. One of the most significant effects of the Chernobyl accident was an increase in thyroid cancer in children through ingestion of milk contaminated with* ^{131}I*. 20,000 agricultural and domestic animals slaughtered immediately, the remainder evacuated. Due to lack of forage and animal care infrastructure, and additional 120,000 animals were slaughtered from May to June 1986.* ***Discuss the EPA Protection Action Guidelines for food and water and soil. Also compare and contrast the guidance provided by the ICRP following the Chernobyl incident.***

Subtle message is that there is not one right answer. That international standards may vary from US and that state and local standards may vary even more.

Need to discuss the DHS Optimization process as well as the recent ICRP optimization document – compare and contrast – even think about the CERCLA process.

CDC recommendations – immediate: ***Stay away from providing recommendation. Simply refer to the site for guidance.***

- *Food and water supplies most likely will remain safe. However, any unpackaged food or water that was out in the open and close to the incident may have radioactive dust on it. Therefore, do not consume water or food that was out in the open.*
- *Food inside cans and other sealed containers will be safe to eat. Wash the outside of the container before opening it.*

c. Food –Most effective countermeasures were restriction of geographically based pasture grasses from animal diets, rejection of milk based on radiological monitoring. Short-term effectiveness was hindered by lack of timely information and an economic issue for private farmers. Larissa has stories about how even uneducated people were smart enough to eat pre-event canned goods rather than fresh food bought in stores.

Dietary additives:

Potassium Iodide (KI): *As noted above, thyroid cancer was one of the primary issues in the immediate aftermath of the Chernobyl incident. Mikhail Balinov of the IAEA lists provision of KI to residents of Pripyat as one of the key successes of the initial response to the disaster. KI was not provided to surrounding areas.* ***KI is most likely to be needed following a NPP or IND incident because it is created in nuclear reaction.***
An RDD does not contain nuclear reactions. This is not an issue for long-term recovery since its half-life is only 8 days.
Virtually all is gone with 80 days. Long-term recovery is concerned mostly about the longer lived radionuclides like cesium-137 or strontium-90.

CDC recommendations:
In the case of internal contamination with radioactive iodine, the thyroid gland quickly absorbs this chemical which can then injure the gland. Iodine in non-radioactive KI blocks radioactive iodine from being absorbed by the thyroid gland.

Iodized table salt also contains iodine, but table salt does not contain enough iodine to block radioactive iodine from getting into your thyroid gland. You should not use table salt as a substitute for KI.

Where can I get KI? KI is available without a prescription. You should talk to your pharmacist to get KI and for directions about how to take it correctly. Your pharmacist can sell you KI brands that have been approved by the FDA.

Prussian blue *Prussian blue traps radioactive cesium and thallium in the intestines and keeps them from being re-absorbed by the body. CDC has included Prussian blue in the Strategic National Stockpile, a special collection of drugs and medical supplies that CDC keeps to treat people in an emergency. [Note – I can't get to that site to find out what-all they have there. Would be a good idea to mention some details of this as a way to demonstrate some preparation for such incidents]* ***Why PB for long-term recovery? This was used on animals and people to increase excretion of the Cs in the bodies. Hence, meat concentration were low, human doses were lower, etc. so PB has a potential for long-term recovery. See CDC website for proper application following a cesium event.***

d. Dietary additives – Larisa and Vira may well have recollections about what sort of things people did in addition to avoiding certain foods. There was a tale about using vodka to flush radioisotopes from the body. *I don't know if it would work, but it would certainly make you feel better!*

Children/pregnancy**: **We can touch this, but will have to treat this hot-button topic sensitively to avoid offense. My gut tells me that we have plenty of material, and should probably drop this controversial bit, unless Vira and/or Larisa feel strongly. We could tie this in with the general lack of reliable information and lack of trust. *Pregnant women, babies, and infants are highly sensitive to environmental contaminants. We now know that many individuals terminated pregnancies in the aftermath of the disaster, either as their own decision or under the advice of physicians.*

CDC: Unborn babies are particularly sensitive to ionizing radiation during their early development, between weeks 2 and 15 of pregnancy. The health consequences can be severe, even at radiation doses too low to make the mother sick. Such consequences can include stunted growth, deformities, abnormal brain function, or cancer that may develop sometime later in life.

e. Children\Pregnancy – Larisa and perhaps Vira have recollections of how a large number of pregnant women chose to terminate pregnancies to avoid perceived problems for babies, sometimes on the advice of physicians.

The Long-term Response (15 min) – This section should discuss the longer-term mitigation actions after the evacuation was complete, the fires were out, and things were settling down to a new state of normalcy. We could restate the distance, time, and shielding mantra here: 80% of total dose was received within 3 mo of incident (Hinton et. al. p.430). We can discuss the radioisotopes that are most problematic – ^{137}Cs, ^{90}Sr. ^{131}I is mostly gone by now.

What is EPA's role here? National Response Framework language.

1. ***Environment***
   a. ***Urban areas***
   b. ***Agriculture (FDA)***
   c.

a. Food supply – Greatest long-term problem is radiological contamination of milk and meat (Balinov p.388) *[Note that rural food supply in Soviet Union made local sourcing more prevalent than in U.S. today. Our centralized food system would make isolating affected foodstuff a lot easier.]* "Effects of the disaster were profound and long-lasting. As recently as 2001, 9% of the milk supply in the affected areas did not meet the standards for ^{137}Cs (Alexakhin et. al. p. *422)*" ***We should have a small presentation on the isotopes of concern:Cs – binds quickly with concrete, Sr –, Po-***

Here are techniques used in the long-term (post-1987)

- *Withdrawal of areas from agricultural use based on radiological surveys,*
- *Soil treatment to reduce Cs and Sr uptake,*
- *Cesium binder dietary supplements to animal feed*

- *intensive fertilizer use to dilute plant radioactivity*
- *change in fodder crops to species that uptake less Cs and SR (ex: rapeseed)*
- *clean feeding – substitute fodder from uncontaminated areas before slaughter and milking.*

Most effective long-term countermeasures treatment of fodder land, clean animal feed, intro of cesium binders (Prussian blue) into animal feed (Balinov p. 388). Other countermeasures included application of organic and mineral fertilizers and agroameliorants, ferrocyanide compounds in farm animals, preslaughter cattle feed w/ clean feedstock, storage of milk in dried or condensed forms to allow ^{131}I decay (Alexahkin et. al p. 421). Disintegration of USSR and accompanying economic hardship reduced effectiveness.

Questions: Ask if Larisa and Vira have recollections about restrictions on food supplies, stories about economic hardship for local farmers and their response, etc.

b. **Forests** – Not given much attention initially. Long-term countermeasures include restrictions on access and use of forest products (mushrooms, berries, and wild game harvesting, firewood), suppression of forest fires to avoid secondary deposition (IAEA p. 87), and alteration of hunting practices (seasonal harvesting) (Balinov p. 388).

Questions: I'm sure that Larissa and Vira have many stories to tell about this proud Russian tradition.

c. **Aquatic systems** – divided into drinking water and contaminated aquatic foods.

Drinking water - Weeks after accident, Kiev drinking water supply switched from Dnieper River to Desna River via a pipeline; Water treatment is designed to remove particulates, but Kiev added activated charcoal and zeolites to treatment system as polishing step. Initial release of water from Kiev reservoir to allow room to contain contaminated runoff; standard soil erosion countermeasures were implemented, but not completely effective because Cs and Sr were in dissolved phase. Countermeasures to prevent transfer of radionuclides from soil to water generally expensive and ineffective. Most effective: Early restriction of drinking water and alternate water supplies (groundwater?). (Balinov) Other countermeasures – Dikes & channel barriers to reduce sediment mobility, addition of sorbents to water (Alexahkin et. al p. 423).

Aquatic foods – similar to forest management; Fish advisories still in place and effective in Scandinavia and Germany, but perhaps not in Russia, Belarus, and Ukraine because of economic motivations to harvest fish (i.e. they're free). Cooking methods (remove skin and bones because of Cs concentrations)

Questions: Similar to above – recollections of concerns about drinking water and aquatic foods, any thoughts on effectiveness of restrictions?

d. **Radiation-induced effects on plants and animals** – *Suggest we skip this, as we have plenty of other material.* Balinov has a nice discussion (p. 389). Alexakhin talks about pine mortality and forest succession (p. 423). Hinton et. al. talks about albino barn swallows (p. 433) Could touch on the "after we're gone" business about how the wildlife has rebounded in the exclusion zone since people are no longer hunting and competing for resources, but ecosystem effects seem peripheral to our story.

e. **Decontaminating Urban infrastructure –** We state up front (and we believe) that an urban area will be target of RDD, so we need to devote some time to this discussion. *An intentional detonation of a nuclear device is likely to take place in an urban area, and is thus quite different from the rural environment surrounding the Chernobyl plant. One of the most significant affects of the Chernobyl accident was contamination of locally grown food, which is unlikely to be a significant concern in a modern American city. Nevertheless, the Chernobyl disaster contaminated several urban areas (including Kiev), and lessons from the urban decontamination effort following Chernobyl are relevant for a dirty bomb scenario in the U.S.*

Large scale decontamination of urban areas was carried out during the first years after the disaster, and was usually carried out by military personnel. In the early period after the incident, inhalation of dust particles was of particular concern, and the CEZ and power plant areas were sprayed with organic solutions to create a thin film that would immobilize dust in the most contaminated areas. In addition, city streets were washed frequently and sprayed with water, which had the effect of suppressing dust and concentrating radionuclides in sewer system. Streets in Kiev were washed daily following the accident

In surrounding areas, activities included washing buildings and roads with special solutions, removing contaminated soils (especially along drip lines next to buildings), and decontamination of reservoirs. The activities focused on schools, hospitals and other buildings with high numbers of people. About 1000 settlements were treated and tens of thousands of public buildings and residences

From this extensive urban decontamination experience, we can discuss the most effective techniques to reduce contamination. A significant fraction of dose was concentrated in soil, on coated surfaces such as asphalt and concrete, and to a lesser extent on roofs and walls. Street cleaning, removal of trees and shrubs, and plowing soils in yards are efficient and inexpensive means of achieving significant reductions of dose (according to IAEA). Roofs and walls also contribute to dose, but are costly and difficult to clean.

Based on accumulated experience, IAEA recommends:

- *Removal of the upper 5–10 cm layer in front of residential buildings, around public buildings, schools and kindergartens, and from roadsides inside a settlement. The removed, most contaminated, layer of soil should be placed into holes specially dug on the territory of a private homestead or on the territory of a settlement. The clean soil from the holes should be used to cover the decontaminated areas. Such a technology excludes the formation of special burial sites for radioactive waste.*

- *Private gardens should be treated by deep plowing or removal of the upper 5-10 cm layer of soil. By now, vegetable gardens have been ploughed many times, and the activity distribution in soil will be uniform in a layer 20–30 cm deep.*

- *Covering the decontaminated parts of courtyards, etc., with a layer of clean sand, or, where possible, with a layer of gravel to attenuate residual radiation.*
- *Cleaning or replacement of roofs.*

Questions: Similar to above – We can discuss washing down buildings, porous materials like brick, and so forth. Larissa has recollections about this in Kiev.

Epilogue: U.S. response to a similar incident (5 min) – A reassuring message that EPA/NDT has been considering responding to such incidents and has plans in place to avoid major pitfalls experienced at Chernobyl. We have technologies here that they didn't have, and have preparation that they did not (ex: stockpiles of KI, cesium binders; organizational structure to transmit info). *[John is knowledgeable about this material, and I assume has great ideas about what this message needs to be.]*

The most relevant ICRP guidance [4.10] recommended some generic two level criteria for intervention in the early accident phase — for sheltering, 5–50 mSv of whole body dose or 0–500 mSv to particular organs; for administration of stable iodine aimed at thyroid protection against intake of radioiodines, 50–500 mSv to the thyroid; for evacuation, 50–500 mSv of whole body dose or 500–5000 mSv to particular organs. For the intermediate accident phase, the generic criteria of 5– 50 mSv of whole body dose or 50–500 mSv to particular organs were recommended for control of foodstuff contamination with radionuclides, and 50–500 mSv of whole body dose for relocation.

Recommendations	EPA PAGs	ICRP (reference 4.10)
Sheltering		50 mSv WB
		500 mSv Org
Iodine Protection		500 mSv Thy
Evacuation		500 mSv WB
Intermediate Phase		
Control Food		10 mSv/a
Relocation		1000 mSv

The annual limits of exposure were substantially (by a factor of 2.5–5) reduced and established equal to 20 mSv for workers and 1 mSv for members of the general public [4.13]. The latter value is currently perceived as a safe level of human exposure.

The ICRP discarded the previous two level intervention criteria and recommended instead some intervention levels (in terms of averted effective dose) — 50 mSv for sheltering, 500 mSv (thyroid dose) for administration of stable iodine, 500 mSv for evacuation, 1000 mSv (lifetime dose) for relocation and 10 mSv/a for the control of foodstuffs.

it proposes the value of the 'existing annual dose', including external and internal doses from natural and human-made radionuclides, of 10 mSv as the generic dose below which intervention is not usually expedient. This does not exclude intervention at lower doses if site specific optimization analysis proves it to be expedient. Inter alia, the ICRP recommended a generic intervention exemption level for radionuclides in commodities dominating human exposure equal to 1 mSv/a.